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Review of the doctoral dissertation

prepared by **M.Sc. Pascaline Aimee Uwineza**

titled: "**Use of natural extracts from Lamium album in the biological protection of cereals against Fusarium pathogens**"

conducted at the Department of Chemistry

of the University of Life Sciences in Poznań

under the supervision of Prof. Dr hab. Agnieszka Waśkiewicz

This opinion was prepared to assess the fulfillment of the conditions set for a doctoral dissertation in the procedure for awarding a doctoral degree in light of the applicable provisions of law, defined in the Act of 20 July 2018—The Law on Higher Education and Science.

Resolution No. 3/IV/2024 of the Scientific Council of the Discipline of Food Technology and Nutrition of the Poznań University of Life Sciences, dated 28 November 2024, was the formal and legal basis for this review.

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Selection of the topic of the doctoral thesis

To ensure the quality and high yields of cereals—an essential source of nutrients for both humans and animals—it is crucial to adopt protective measures that mitigate mentioned plant diseases. Phytopathogenic fungi, particularly those belonging to the *Fusarium* genus, pose significant threats to cereals at various stages of growth and during grain storage. These fungi can lead to substantial agricultural losses, diminish the quality and technological value of grain, and compromise the health safety of these raw materials through the production of mycotoxins. *Fusarium culmorum* and *Fusarium proliferatum* are identified as major pathogens affecting cereals in Europe. The use of synthetic fungicides—pesticides that inhibit the activity of these fungal pathogens—is common in conventional agricultural

practices. However, there is an increasing urgency to reduce dependence on these substances, given their documented harmful effects on human and animal health, as well as on natural ecosystems. The non-targeted toxicity and persistence of these pesticides contribute to environmental pollution. Furthermore, the lingering presence of pesticide residues can lead to the development of resistance among environmentally adaptive microbial phytopathogens.

The global trend of population growth underscores the urgent need to enhance agricultural productivity. This challenge is further complicated by the limited availability of arable land and the impacts of climate change. Concurrently, the European Green Deal strategy and the "From Farm to Fork" initiative emphasize the necessity of eliminating chemical pollutants from the environment and transforming the current EU food system into a more sustainable model, which includes reducing pesticide use.

Biocontrol strategies, which exploit competitive relationships among living microorganisms or harness the antimicrobial properties of plant substances, are being explored as viable alternatives to synthetic plant protection products for combating diseases of microbiological origin. Although plant extracts have demonstrated potential effectiveness against plant diseases, most research has concentrated on their activity in controlled laboratory environments (*in vitro*) or in plant studies (*in planta*), leaving a gap in data from real on field cultivation conditions.

In her doctoral thesis, **Ms. Pascaline Aimee Uwineza** investigated the potential of extracts from the flowers of the herbal medicinal plant *Lamium album* to inhibit the growth and mycotoxin synthesis of the molds *Fusarium culmorum* and *Fusarium proliferatum.* Her research encompassed both laboratory studies and experimental field trials.

In conclusion, I believe that the topics and research areas explored are crucial for developing new solutions that minimize the risks related to microbiological food safety. This work aligns with current research trends in the fields of food technology and nutrition.

Presentation of information about the doctoral dissertation concerning the assessment criteria, along with justifications for the evaluations.

The scientific achievement presented by the PhD student, titled "The Use of Natural Extracts from Lamium album in the Biological Protection of Cereals Against Fusarium Pathogens," consists of a collection of five thematically related scientific articles. These articles collectively have an impact factor **IF of 17.900** (as of the year of publication) and a total of **540 MEiN points**. The research findings, along with a review of the theoretical issues related to the work methodology, were published in specialist journals indexed in the Journal Citation Reports (JCR) between 2020 and 2024. Notable publications include articles in journals like: *Molecules*, *Applied Sciences*, *Toxins*, *Frontiers in Microbiology*, and *Agriculture*. The manuscripts are as follows:

P1: ***Uwineza, P.A.****; and Waśkiewicz, A. 2020. Recent Advances in Supercritical Fluid Extraction of Natural Bioactive Compounds from Natural Plant Materials. Molecules 25, 3847. https://doi.org/10.3390/molecules25173847.* ***(IF=4.2, MEiN2024=140)***

P2: ***Uwineza, P.A.****; Gramza-Michałowska, A.; Bryła, M.; and Waśkiewicz, A. 2021. Antioxidant Activity and Bioactive Compounds of Lamium album Flower Extracts Obtained by Supercritical Fluid Extraction. Appl. Sci. 11, 7419. https://doi.org/10.3390/app11167419.* ***(IF= 2.5, MEiN2024=100)***

P3: ***Uwineza, P. A.****; Urbaniak, M.; Stępień, Ł. ; Gramza-Michałowska, A. and Waśkiewicz, A. 2023. Lamium album Flower Extracts: A Novel Approach for Controlling Fusarium Growth and Mycotoxin Biosynthesis. Toxins, 15(11), 651. https://doi.org/10.3390/toxins15110651.* ***(IF=3.9, MEiN2024=100)***

P4: ***Uwineza, P. A****; Urbaniak, M.; Stępień, Ł.; Gramza-Michałowska, A. and Waśkiewicz, A. 2024. Efficacy of Lamium Album as a Natural Fungicide: Impact on Seed Germination, Ergosterol, and Mycotoxins in Fusarium culmorum-Infected Wheat Seedlings. Front. Microbiol. 5, 1363204. https://doi.org/10.3389/fmicb.2024.1363204.* ***(IF=4.0, MEiN2024=100)***

P5: ***Uwineza, P.A.****; Kwiatkowska, M.; Gwiazdowski, R.; Stępień, Ł.; Bryła, M.; Waśkiewicz, A. 2024. Field Assessment of Lamium album in Reducing Mycotoxin Biosynthesis in Winter Wheat Infected by Fusarium culmorum. Agriculture, 14, 647. https://doi.org/10.3390/agriculture14050647.* ***(IF=3.3, MEiN2024=100)***

The publications listed are the result of collaboration among several authors, ranging from 2 to 6 individuals. **In each case, the PhD student Mrs. Pascaline Aimee Uwineza is both the first author and the corresponding author.** Each article includes declarations from the authors regarding their contributions. The works presented in the dissertation demonstrate comprehensive research and methodological approaches, including laboratory tests and field experiments, which justify the collaborative effort. This collaboration enabled the PhD student to test the proposed hypotheses and achieve specific objectives using a well-rounded analytical framework, supported by specialists from various research fields. The cooperation significantly enhanced the research skills of Mrs. Pascaline Aimee Uwineza. **According to the attached declarations, her contributions to the preparation of the articles were substantial.** She played a pivotal role in conceptualizing all studies, developing and validating methods, conducting experimental work, interpreting and discussing the results, preparing the manuscripts, addressing reviewers' comments, and editing the articles accordingly. It is important to highlight that the research received funding from the **National Science Center through the OPUS 16 grant (no.: UMO-2018/31/B/NZ9/03485).** The PhD student also indicated her involvement in project management, which is invaluable experience for an emerging scientist.

In summary, the scope of work undertaken by Ms. Pascaline Aimee Uwineza showcases her ability to conduct independent scientific research and reflects her strong organizational skills.

The dissertation is 124 pages long. It includes 46 pages dedicated to a self-presentation, 5 pages outlining the contributions of individual authors to the preparation of the manuscripts, and the remaining 73 pages presenting the content of the articles that constitute the monothematic

achievement of the PhD student. The self-presentation contains a list of abbreviations used, an abstract in both English and Polish, and a theoretical introduction that familiarizes the reader with the key issues of the work while justifying the purpose of the research undertaken. It also includes a chapter that defines 5 research goals related to the published works (labeled P1-P5) and formulates 4 research hypotheses. In the chapter on research methods, the PhD student briefly summarizes the methodologies of the experiments described in detail in publications P2-P4. This chapter discusses the most important research results and presents the statements and conclusions derived from them. Additionally, the dissertation features a list of source literature, a list of tables and figures, and the texts of the aforementioned publications.

In the Introduction chapter, related to the theoretical issues of all published works (P1-P5), the PhD student characterized the problem related to the development of fungi of the *Fusarium* genus on cereal crops and harvests. She devoted particular attention to the characteristics and negative impact of two species of microscopic fungi - *Fusarium culmorum* and *Fusarium proliferatum*, which are among the most common pathogens of cereals, including wheat. The aforementioned phytopathogens contribute to global food losses, currently exacerbated by climate change. These microorganisms threaten food and feed safety due to the production of toxic secondary metabolites, such as deoxynivalenol (DON) and its derivatives - 3- and 15-acetyldeoxynivalenol (3- and 15-AcDON), nivalenol (NIV), zearalenone (ZEN) and its derivatives, including beta-zearalenol (β-ZOL), alpha-zearalenol (α-ZOL) and zearalenone-14 sulfate (ZEN-14S).

The PhD student **Ms. Pascaline Aimee Uwineza** highlighted that the conventional approach to combating fungal pathogens affecting crops relies on various strategies. These include crop rotation, the use of genetically resistant seeds, and primarily the application of synthetic pesticides known as fungicides. Long-term scientific studies have documented the harmful effects of these substances on human health, animal well-being, and natural ecosystems. **With this in mind, the PhD student emphasized the necessity of developing and implementing sustainable, environmentally friendly agricultural practices in cereal cultivation.** In this context, she proposed the use of natural plant extracts as a means to protect cereals from Fusarium pathogens, which also became the focus of her doctoral thesis.

Plant extracts obtained from various plants and their parts contain a range of secondary bioactive compounds, such as phenolic acids, flavonoids, tannins, terpenes, and alkaloids. These substances can inhibit the growth of pathogenic fungi, either individually or in synergy, by disrupting the oxidative balance of cells, increasing cell membrane permeability, limiting ergosterol synthesis, and reducing the production of mycotoxins essential for pathogen colonization. **The PhD student noted a lack of sufficient data on the impact of natural biopesticides on mycotoxin synthesis.** This gap inspired her research to document the effects of plant extracts on the metabolic activity of Fusarium phytopathogens. She also pointed out the insufficiently studied antimicrobial potential of white dead nettle (Lamium album), an edible medicinal plant commonly found in Europe, West Asia, and North Africa. **Therefore, assessing**

the antifungal activity of Lamium album flower extracts against Fusarium pathogens prevalent in agriculture is both an interesting and logical pursuit.

The PhD student discussed traditional methods for obtaining plant extracts that are rich in bioactive compounds, highlighting their limitations. These limitations include long extraction times, the necessity of using expensive pure solvents, low efficiency, losses of bioactive compounds, and poor extraction selectivity. She also explored the potential of using supercritical solvents, particularly carbon dioxide, for extracting biologically active compounds from plant materials. In the experimental section of her work, the PhD student utilized this extraction technique and provided a detailed analysis **in the review paper [P1]**, which is part of the monothematic cycle of her doctoral dissertation.

Paper P1, linked to the first research objective, compiles information regarding the use of supercritical solvent extraction for isolating bioactive compounds from plant materials. In the article, she discussed the theoretical foundations of extraction with various supercritical solvents, focusing on carbon dioxide, which is the most commonly used. She presented data on how various factors, such as extraction temperature, pressure, type and amount of co-solvent, sample type and size, and extraction time affect the efficiency of the extraction process. She emphasized the necessity of optimizing these parameters to achieve maximum solubility of the extracted compounds and enhance mass transfer efficiency. The work also includes comprehensive information on using this extraction technique for the selective extraction of plant bioactive compounds, specifically alkaloids, terpenoids, and phenolic compounds. It's worth noting the significant contribution the PhD student made in preparing the study, as it was based on a review of 131 bibliographic sources.

Based on the information presented in the theoretical section of the work and the prepared review article, it is important to highlight that Ms. Pascaline Aimee Uwineza has a strong understanding of current research issues related to her dissertation. This deep knowledge has enabled the PhD student to develop a project that effectively addresses the contemporary challenges in finding new solutions for protecting cereals against pathogens of the *Fusarium* genus. Her thorough exploration of the theoretical aspects of her doctoral topic has allowed her to accurately identify gaps in existing knowledge, which serve as the foundation for her research proposals. Additionally, the bibliography utilized in the preparation of her doctoral dissertation is up-to-date and, in my opinion, does not raise any objections.

The PhD student has defined the following research objectives for the work:

1. To develop and optimize the extraction conditions of Lamium album flowers using supercritical carbon dioxide (SC-CO2), with methanol as a co-solvent. This includes assessing the effects of temperature, pressure, CO2 flow rate, and extraction time on the yield and composition of the extract (P1 and P2).

2. To characterize the bioactive compounds in Lamium album flower extracts by analyzing the content of volatile and phenolic compounds, as well as evaluating their antioxidant activity. This will help establish a detailed metabolomic profile of the extracts and assess their overall antioxidant capacity (P2).
3. To conduct in vitro assessments of the antifungal activity of Lamium album flower extracts at different concentrations, measuring their ability to inhibit the growth of the mycelium of selected Fusarium species (F. culmorum and F. proliferatum) and their impact on the biosynthesis of mycotoxins (P3).
4. To investigate the phytotoxic effects of L. album flower extracts at various concentrations on wheat seed germination and seedling growth, in order to determine any potential negative impact of these extracts on wheat when used as a protective measure (P4).
5. To assess the in vivo antifungal potential of L. album flower extracts against F. culmorum infections in wheat, through controlled growth conditions and field experiments involving selected winter wheat cultivars (Julius and Arkadia) (P4 and P5).

Ms. Pascaline Aimee Uwineza formulated the following research hypotheses:

H1: The volatile and phenolic compounds, as well as the antioxidant activity of Lamium album flower extracts, significantly depend on the supercritical carbon dioxide (SC-CO2) extraction conditions, which include temperature, pressure, CO2 and co-solvent flow rates, and extraction time. Optimizing these parameters enhances the quality of the extracts.

H2: The in vitro antifungal activity of Lamium album flower extracts against Fusarium culmorum and Fusarium proliferatum is influenced by both the concentration of the extract and the specific Fusarium species

H3: Lamium album flower extracts may have phytotoxic effects on wheat seed germination and seedling growth, with the degree of impact varying based on the extract concentration. This finding provides insight into the safe levels of extract usage for biological control in agricultural settings.

H4: The application of Lamium album flower extracts may demonstrate in vivo antifungal potential against F. culmorum infections in wheat seedlings, both under controlled growth conditions and in field trials with winter wheat cultivars, by potentially inhibiting fungal infections and mycotoxin biosynthesis.

I would like to point out that the PhD student did not link the formulated research hypotheses with relevant publications, which would have made it easier to assess the accuracy of their verification. However, they were connect the statements and final conclusions presented in her self-presentation.

In her work P2, which relates to the first and second research objectives and the first research hypothesis, the PhD student presented experimental results on how the extraction conditions of dried *Lamium album* flowers affect the antioxidant activity and chemical composition of the extracts. The extracts were characterized in terms of antioxidant activity using standard spectrophotometric tests, including DPPH, ABTS, and FRAP tests. The total phenolic content was determined using the Folin–Ciocalteu test, while the amounts of 16 specific phenolic compounds—such as myricetin, quercetin, rutin, caffeic acid phenethyl ester, apigenin, pinocembrin, pinostrobin, galangin, chrysin, vanillic acid, syringic acid, trans-3-hydroxycinnamic acid, and trans-cinnamic acid—were analyzed using UPLC/PDA-TQD chromatography. The best

antioxidant properties, which correlated with the highest content of phenolic compounds, were observed in extracts obtained at a process temperature of 50°C, with chrysin, pinostrobin, myricetin, and trans-3-hydroxycinnamic acid being the dominant compounds. The indicated temperature conditions were utilized to obtain extracts for the subsequent stages of the research. **I would like to address the PhD student's statement:** "The results indicate that SC-CO2 can be considered an alternative method of extracting bioactive compounds from *Lamium album*." In my opinion, the PhD student was not justified in referring to the extraction technique as an "alternative method." If it is an alternative, then concerning what? The PhD student did not provide results obtained using other extraction methods.

After reviewing the research objectives, the proposed hypotheses, the methodology of the experimental section, and the obtained results—particularly those in paper P2—I have some comments and questions that are both supplementary and debatable in nature. In Chapter 3 of the dissertation, titled "Methods," the PhD student presented the plant material used in the research, specifically dried flowers of *Lamium album* purchased from the certified company Dary Natury. The student indicated that the plant was selected based on screening tests that determined the antioxidant and antifungal properties of the extracts. **However, it is unclear whether the PhD student was referring to her own unpublished research or to a literature review included in work P1. I would appreciate an explanation regarding the approach used, considering the information provided on page 12, in paragraph 1 of Chapter 4, titled *"The Most Important Results with Discussion."***

Analyzing the methodology of the experiments conducted and the research results related to objective 1 and the first research hypothesis (H1), I must note that the PhD student only partially achieved the first objective and only partially validated the first hypothesis. In article P2, she documents an independent assessment specifically regarding the effect of process temperature (40°C, 50°C, and 60°C) on the extraction of bioactive compounds from Lamium album flowers using supercritical carbon dioxide combined with methanol. According to the methodology described, the other process parameters remained constant: the pressure was set at 250 bar, CO2 flow at 4 ml/min, methanol flow at 1 ml/min, and extraction time at 180 minutes. I noticed that there are no results for pressure values other than 250 bar, even though the PhD student indicates in the methodology that pressure was also tested at 300 bar. Similarly, there is no data for solvent flow values and extraction times beyond those specified. I am curious about the origin of this discrepancy. It seems that some results may not have been published or included in the self-report.

I noticed that the PhD student used varying amounts of raw material to extract bioactive compounds at different stages of the study while keeping pressure, temperature, solvent flow, and extraction time constant. Specifically, the P2 publication reported the extraction from 2g of raw material, the P3 paper from 9g, and the P5 paper from 10g of dried flowers. Given that the amount of raw material influences extraction efficiency, I find it concerning that there seems to be no clear understanding of the methodological approach used. Additionally, the composition and

antioxidant activity of the extracts were only detailed in the P2 paper. **I wonder if the PhD student shares my concerns about the comparability of the compositions of the different extracts. Could the variations in composition have affected the antimycotoxic activity results presented in the P5 paper?** I also question why a larger quantity of the extract was not prepared in lyophilized form for use in different stages of the study, especially considering the need for repetitions.

I would like to request clarification on how the PhD student defines the efficiency of the extraction method used, as I did not find an explanation in the work. Specifically, I am curious whether the PhD student determined the dry matter content in the extracts obtained at different process temperatures, and then evaluated the proportion of bioactive compounds within the dry mass. Including this information would not only be interesting but also important for preparing dilutions with the desired extract concentration.

I would like to emphasize that the PhD student was not entirely clear in linking aim 2 of the research to publication P2. The referenced manuscript did not include the results of the analysis of volatile compounds extracted from the flowers of the studied plant; instead, these results were only presented in the work's self-presentation. It might be worthwhile to consider preparing another publication that incorporates the findings from the analysis of the volatile compounds identified in the studied extracts.

In the P3 paper, related to the third research objective and hypothesis H2, the PhD student presented the results of in vitro studies on the effectiveness of *Lamium album* flower extract in inhibiting the growth and limiting the synthesis of ergosterol and mycotoxins by two strains of microscopic fungi: *F. proliferatum* (PEA 1) and *F. culmorum* (KF 846). These strains were chosen due to their significant impact on cereal quality in Europe, particularly in Poland. The antifungal activity of the extract was assessed at various concentrations (2.5%, 5%, 7.5%, and 10%) by culturing the selected molds on PDA medium supplemented with the respective doses of the extract. The extract from *L. album* flowers inhibited the growth of the tested molds in a dose- and strain-dependent manner. For *F. culmorum*, growth inhibition ranged from 0% at 2.5% extract concentration to approximately 30% at 10%. In contrast, for *F. proliferatum*, inhibition ranged from approximately 28% to 43% for the same concentrations. The ergosterol content in the mold biomass was most significantly reduced in the presence of 10% extract, showing an approximate reduction of 89% for F. culmorum and about 93% for *F. proliferatum*. A noteworthy reduction in mycotoxin synthesis was also observed for both strains compared to control samples. The extent of this reduction depended on the extract dose, the specific mold strain, and the type of mycotoxin. For *F. proliferatum*, the synthesis of several mycotoxins was reduced: beauvercin (BEA) (48.50–86.76%), FB1 (39.35–87%), FB2 (31.48–81%), and FB3 (51.51–90%). For *F. culmorum*, reductions were noted in the synthesis of DON (44.39–96.41%), 3- and 15-AcDON (61.64–96.94%), ZEN (49.38–89.71%), ZEN-14S (52.33–92.61%), β-ZOL (55.57–99.86%), α-ZOL (68.42–100%), and FUS-X (55.57–99.51%). Considering the scope of the analyses conducted, I believe that aim no. 3 of the work should include an examination of the effect of *Lamium album* flower extracts on ergosterol

biosynthesis. The PhD student addressed this topic in papers P3, P4, and P5. In the P3 manuscript, the PhD student emphasized that the reduction in ergosterol content does not always correlate with the reduction of mycotoxin synthesis and *vice versa*.

In the work P4, which relates to the fourth research aim and hypothesis H3, the assessment of the effects of Lamium album flower extract applied at concentrations of 5% and 10% on seed germination and the growth of wheat seedlings was presented in a controlled pot experiment. The PhD student made a valid assumption about the potential adverse effects of the extract on wheat growth, which could occur alongside its antifungal properties. For this experiment, wheat seedlings were artificially inoculated with spores of the mold *Fusarium culmorum*. An analysis was conducted to evaluate various growth parameters of the seedlings, focusing on the percentage of seed germination, as well as the lengths of the roots and shoots. Additionally, the contents of ergosterol and mycotoxins in the roots and leaves of the tested wheat were measured. The results indicated that *L. album* flower extract had a slight phytotoxic and allelopathic effect, impeding seed germination and seedling growth. However, it also effectively reduced *F. culmorum* infection, completely inhibiting the synthesis of deoxynivalenol (DON), 3-acetyldeoxynivalenol (3-AcDON), and 15-acetyldeoxynivalenol (15-AcDON), while significantly affecting zearalenone (ZEN) and ZEN-14S. A decrease in ergosterol content was observed in the roots of the seedlings, confirming the negative impact of the extract on *F. culmorum* development. **It is worth highlighting the interesting, in-depth, and critical analysis and discussion of the results presented in the P4 publication.** This work reflects the PhD student's growing scientific maturity as they progressed through their research.

In the work P5, associated with objective 5 of the research and hypothesis 4, the PhD student documented the results of experiments conducted at the Field Experimental Station of the Institute of Plant Protection - State Research Institute in Winna Góra. The research was carried out during the 2022/2023 season on two varieties of winter wheat, Arkadia and Julius, and focused on assessing the effectiveness of an extract from *Lamium album* flowers applied as a foliar spray against the mycotoxin-producing species *F. culmorum*. A significant reduction in ergosterol content was observed in both wheat varieties treated with the plant extract. The Arkadia variety displayed greater resistance to Fusarium infection, while the antifungal activity of L. album was more pronounced in the Julius variety. This highlights the importance of genetic factors in the interactions between plants and fungi, and underscores their significance in developing effective solutions for combating crop diseases. Moreover, the Julius wheat variety exhibited a higher accumulation of mycotoxins compared to Arkadia. The plant extract was found to limit the biosynthesis of all analyzed mycotoxins (DON, 3-/15-AcDON, ZEN, ZEN-14S) in both wheat varieties, with Arkadia being the most affected, particularly regarding the mycotoxins deoxynivalenol (DON) and zearalenone (ZEN). **Out of curiosity, I would like to know if the use of the plant extract would be comparable to using a synthetic agent for the same crop area in**

achieving a similar level of antifungal protection? I am interested to find out whether the PhD student made such a comparison.

In her self-presentation, the PhD student included additional, unpublished results from a comparative analysis of the effects of different wheat grain sterilization methods (autoclaving and microwave exposure) on the effectiveness of Lamium album extract in inhibiting the growth of *Fusarium culmorum*. These findings indicate that the microorganisms present in the grain compete with phytopathogens of the Fusarium genus, thereby limiting their growth and the biosynthesis of mycotoxins.

In my opinion, papers P4 and P5 represent the most significant components of the PhD student's research. They present crucial results concerning the potential use of natural extracts derived from the locally available herbal plant *Lamium album* for the biological protection of cereals, specifically against *F. culmorum*, one of the most prevalent cereal pathogens in Europe. It is important to continue this research, particularly in terms of estimating the economic implications of the proposed solution.

In summary, I believe that the research carried out has yielded very interesting results that provide an original approach to a scientific problem related to the quality and microbiological safety of cereals. Any comments and concerns I have regarding the assessed work are intended to be constructive.

Final assessment conclusion

In my opinion, the dissertation submitted for review by Ms. Pascaline Aimee Uwineza, titled "The Use of Natural Extracts from Lamium album in the Biological Protection of Cereals Against Fusarium Pathogens," meets the requirements for doctoral dissertations as defined in the Act of July 20, 2018 - The Law on Higher Education and Science, along with its subsequent amendments. Therefore, I submit to the Scientific Council of the Discipline of Food Technology and Nutrition at the University of Life Sciences in Poznań a request for its acceptance and for the admission of the author to the next stages of the proceedings to obtain the degree of Doctor of Agricultural Sciences in the discipline of Food Technology and Nutrition.

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